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Description

Method and device for allocating channels in a communications system with CDMA subscriber separation

The invention relates to a method and a device for allocating channels in a communications system with CDMA subscriber separation.

In a communications system, a channel describes a link from a message source (transmitter) to a message sink (receiver). The information which is to be transmitted is usually encoded, modulated and amplified at the transmit end so that after transmission, which generally entails attenuation and distortion, said information can be evaluated at the receive end by means of measures corresponding to the transmit end.

The transmission medium used can be a line or a radio interface. In the latter case, radio communications systems are referred to, and these have become widespread in the form of mobile radio systems.

In radio communications systems, information (for example voice, image information or other data) is transmitted using electromagnetic waves via a radio interface between the transmitting and receiving radio stations (base station and mobile station, respectively). The electromagnetic waves are emitted here with carrier frequencies which lie in the frequency band which is provided for the respective system. Frequencies in the approximately 2000 MHz frequency band are provided for future mobile radio systems with CDMA or TD/CDMA transmission methods via the radio interface, for example the UMTS (Universal Mobile Telecommunication System) or other 3rd Generation systems.

FDMA (frequency division multiple access), TDMA (time division multiple access) or CDMA (code division multiple access) subscriber separation methods are used to discriminate between the signal sources, and thus to evaluate the signals. These separation methods can also be combined. In the CDMA subscriber separation method the channels are distinguished by means of the individual CDMA codes.

Channel allocation methods describe a strategy of allocating the channels to the individual links so as to make best possible use of the radio resources of the radio interface, in which process care is taken to ensure that the expenditure on adaptation during the allocation of the channels to the previous links which is due to future changes in the data rate of individual links should be as small as possible. The expenditure on adaptation arises if a CDMA code has to be removed from an existing link and a different CDMA code has to be allocated to said link. This object is achieved for a communications system with CDMA subscriber separation by means of the present invention having the features of claims 1 and/or 14. Advantageous developments of the invention can be found in the subclaims.

In the method for allocating channels according to the invention, the CDMA codes form the channels for links, the CDMA codes which are available for the allocation of channels being derived from one another in accordance with a tree structure. A chip sequence of a higher order CDMA code is thus, for example, a subset of the chip sequence of a lower order CDMA code. The CDMA codes are represented by nodes within the tree structure. In one node, a plurality of branches respectively converge and in turn lead to further lower order nodes.

The nodes are represented for the channel allocation method by means of a sequence of symbols, the sequences of symbols of two nodes differing at one position which corresponds to the distance between the two nodes and their joining node within

the tree structure. A small position means that two nodes differ greatly, and thus a difference already occurs near to the root of the tree structure. In other words, the joining node (father node) is near to the root in this case. Free nodes and assigned nodes are distinguished, a free node designating a non-assigned CDMA code and an occupied node designating an assigned CDMA code. Only non-assigned CDMA codes can be allocated.

For the allocation of a free CDMA code to a link, all the free nodes which are not connected to an already occupied node directly in the upward or downward direction in the tree structure, i.e. differ from an already occupied node in at least one symbol, are selected in a first step. It is not permissible to allocate any CDMA code whose chip sequence is a precise subset of a CDMA code which has already been assigned or of which the chip sequence of a CDMA code which has already been assigned forms a subset.

In a further step, the position in the sequence of symbols at which a difference from an already occupied node occurs is determined for the selected nodes, starting in each case with the root of the tree structure. The position is consequently a measure of the discriminating power of two CDMA codes. If two CDMA codes differ greatly, the data rate can be increased for one of the CDMA codes without a collision with the second CDMA code occurring. Furthermore, a sum of the positions is determined for all the occupied nodes, and the channel with the CDMA code which corresponds to the node of the predefinable sum is allocated. The allocation strategy is thus related to the discriminating power with respect to all the other CDMA codes, i.e. to the sum of the instances of discrimination.

The tree structure is advantageously constructed in such a way that the distance between a node and the root corresponds to an increase

in the spread factor of the CDMA code, and thus directly to a reduction in the data rate for the link. The data rate can be increased without adapting the allocation of the other CDMA codes only by changing a CDMA code in that the existing node is removed and a new node is allocated within the tree structure starting from the existing node in the direction of the root.

An advantageous development of the allocation strategy provides for the predefinable sum to be the smallest of the sums. This ensures that the CDMA codes differ greatly, thus providing the possibility of the data rate for the link with the newly allocated CDMA code being increased to a maximum degree in future without adapting the rest of the allocation process.

The objective is different if no increase, or only a limited increase, in the data rate is possible or desired for a large number of connections, for example for subscribers with a fixed basic data rate. Here, it is advantageous that the predefinable sum is the greatest of the sums. CDMA codes which do not differ greatly are thus assigned, that is to say parts of the tree structure are kept free for further links with possibly higher data rates.

A mixed form of the previous two strategies provides for an increase possibility to be defined for a data rate of the link, and for a node with a difference from an already occupied node at a specific position to be selected, the position corresponding to the increase possibility. The possibility of increasing the data rate is expressed in the tree structure in the number of nodes which can be displaced in the direction of the root (a node before the joining node with an already occupied node) without a collision occurring with a CDMA code which has already been assigned. If the increase possibility is known in advance,

a part of the tree structure which is just sufficient, i.e. not too much and not too little, can therefore be reserved.

In addition, an increase possibility for the links for the already occupied nodes is advantageously taken into account in the selection of the node. The increase possibilities for the existing links are therefore not affected.

The method can also be implemented in a multi-stage way. Thus, one advantageous development of the invention provides for a plurality of channels with different CDMA codes to be allocated, a desired data rate resulting from the totality of the individual data rates of the CDMA codes. The free nodes of the tree structure can nevertheless be well utilized with a high utilization rate, i.e. occupancy of the nodes.

For digital systems which are widespread the symbols are digital values. From each node a branch branches off in the direction of the root and two branches branch off in the opposite direction. A mapping of the CDMA codes onto the tree structure which can be implemented particularly easily provides for the two following nodes of the outgoing branches to be mapped, starting from the root of the tree structure, by means of an additional "0" or "1" in the sequence of symbols, the number of bits corresponding to the sequence of symbols with the spread factor. Irrespective of the overall construction of the CDMA codes, the digital tree structure is organized in a very clear way. The CDMA codes are, for example, orthogonal codes (OVSF) with a variable spread factor. As a result, detection on the receive side is made easier because such CDMA codes continuously support optimum decorrelation.

Although a channel assignment system according to the invention can be used in a very wide variety of communications systems, use in the downward direction of a radio interface in a broadband radio communications

system is particularly advantageous. Such a radio interface is designed for a 3rd mobile radio generation and it can support a larger number of channels. The greater the number of channels, the more important it is to have a good assignment strategy.

According to further advantageous embodiments of the invention, a desired data rate and/or increase possibility for a data rate of the link is derived from an identifier and/or from a signaled request of a mobile station. The increase possibility can thus be determined precisely for the mobile stations, in accordance with the current link profiles and service profiles, so that only free spaces in the tree structure which are necessary and useful are reserved in the assignment strategy.

The invention is explained below in more detail by means of an exemplary embodiment and with reference to drawings, in which

Fig. 1 shows the structure of orthogonal CDMA codes with a variable spread factor,

Fig. 2 shows a tree structure representing the CDMA codes,

Figs 3 - 5 show allocation strategies for the allocation of channels, and

Fig. 6 shows a schematic representation of a mobile radio system.

In communications systems with CDMA subscriber separation, the different links can be distinguished by means of an individual CDMA code with which the signals of the links are spread. An example for such a communications system is a digital radio communications system with broadband channels which is known from "UTRA Physical Layer Description FDD parts", v0.4, dated June 25, 1998.

For the downlink direction, i.e. for a radio transmission from base stations to mobile stations, orthogonal codes with a variable spread factor OVSF and with a fixed chip rate of 4.096 Mcps according to fig. 1 are used. The orthogonal codes with a variable spread factor OVSF can be represented in a tree structure, the individual CDMA codes being derived from one another within the tree structure.

From one level of the tree to another the number of chips per CDMA code, and thus the spread factor SF, doubles. Starting from the CDMA code with the chip sequence (1, 1) two CDMA codes of the next lowest level (1, 1, 1, 1) and (1, 1, -1, -1) are derived. The first half (1, 1) is accepted and the second half either accepted (1, 1) or accepted in inverted form (-1, -1). This produces a code family over, for example, eight levels. Within the eight levels there are 508 different CDMA codes with eight different data rates (2048 Kbit/s with a spread factor SF = 4, 1024 Kbit/s with SF = 8, 512 Kbit/s with SF = 16, 256 Kbit/s with SF = 32, 128 Kbit/s with SF = 64, 64 Kbit/s with SF = 128, 32 Kbit/s with SF = 256). For example, a 32 Kbit/s gross data rate is needed to encode voice information with an 8 Kbit/s net data rate and transmit it via the radio interface with error protection.

Within the level with a spread factor SF = 256 there are 256 different CDMA codes, and at the next highest level there are 128 CDMA codes etc. The CDMA codes are allocated in accordance with the data rate required by the link. If all the CDMA codes are still free, i.e. in the run-up phase, one of the CDMA codes can be allocated at random. However, if some of the CDMA codes have already been assigned, peripheral conditions have to be taken into account in the allocation of a CDMA code which is still free to a new link.

The CDMA codes which are used within a frequency band in a radio cell must

differ at least in part of their chip sequence. Furthermore, changes in the data rate of a link must be allowed for in a predictive fashion, and CDMA codes of a higher level must not be blocked by the new allocation of a lower level CDMA code.

Thus, for the orthogonal codes with a variable spread factor OVSF, a representational form of a tree structure according to fig. 2 which designates the nodes of the tree with a digital signal sequence is selected. Starting from a node, for example 11, a "1" is added for the upper branch which goes away from the root, and a "0" is added for the lower branch. This simplifies evaluation of the tree structure because the number of positions of the sequence of symbols thus corresponds directly to the level of the node (and of the spread factor SF) in the tree.

To make a comparison of nodes, which is necessary for the algorithms explained below, the position of departure should be the root of the tree. However, for the person skilled in the art it is self-evident that a respectively inverted evaluation is also possible.

If, for example, the nodes
1110 and
1101 are compared with one another, a difference occurs at the third position from the left. Later differences are not of interest.
For 10 and
1101 it is the second position. In the extreme case, the difference occurs at the eighth position (compare 11111110 and 11111111). The comparison is thus left-aligned.

If, for example, the nodes
00 and
001 are compared with one another, no difference can be determined. The two nodes do not differ at least

in one symbol. If no difference can be determined, this corresponds to two CDMA codes, which are directly connected to one another in the upward or downward direction in the tree structure.

For the allocation of a CDMA code, all the nodes which have no difference (Hamming distance is equal to 0) in comparison with one of the occupied nodes should be excluded. In other words, a node (1111 in fig. 3) blocks all the nodes (111, 11, 11, 1) arranged in ascending order in the tree, and vice versa.

For the allocation, all the nodes which have a difference from all the occupied nodes are thus selected. Furthermore, only those nodes which correspond to the desired data rate are considered. According to Fig. 3, three nodes (101, 010, 001) are available for a desired data rate of 1024 Kbit/s with SF = 8. A selection must be made between these nodes.

For this purpose, in each case the sum of the positions at which, in comparison with all the already occupied nodes (at least all the occupied nodes of part of the tree structure), the first difference from the left has occurred is used for these three nodes 101, 010, 001. For the node 101 the sum is 9 = 2 + 2 + 3 + 1 + 1, for the node 010 the sum is 8 = 1 + 1 + 1 + 2 + 3 and for the node 001 the sum is 8 = 1 + 1 + 1 + 2 + 3.

The sums are then compared with a predefinable sum. If the predefinable sum is the maximum, the node 101 is selected. If the predefinable sum is the minimum, the node 010 or 001 can be selected. The selection between the two nodes 010 or 001 is random.

The maximum is selected if it is desired to group the occupied nodes, i.e. the allocated CDMA codes, closely to one another (see fig. 4). This has advantages if great changes are not to be expected in the data rates of the links.

The minimum is selected in order to achieve the most uniform possible distribution of all the CDMA codes used in the tree. This has in statistical terms the advantage that it provides a maximum degree of flexibility for a later assignment of higher data rates. According to fig. 3, the benefit of this is not yet felt because it is not possible to simply double the data rate for any of the nodes 101, 010 or 001. However, the links are not permanent so that when a previously occupied CDMA code is released the probability of an increase in the data rate being possible in the future is greater for the nodes 010 and 001 than for the node 110.

Fig. 4 shows links to subscribers with a basic data rate of 32 Kbit/s, for example simple voice links. Increases in the data rate are not expected for these subscribers so that the strategy with the maximum for the predefinable sum is selected. The sum for the free node 11111101 is 34 = 7 + 7 + 8 + 6 + 6, for the nodes 11111001 and 11111000 is the sum 32 = 6 + 6 + 6 + 7 + 7 in each case. The node 11111101 is consequently selected. A later new allocation of the node 1111100 with a higher data rate of 64 Kbit/s is therefore not prevented.

An additional aspect for both strategies arises if not only the desired data rate is used for the link but also a defined increase possibility for the data rate is also known. The desired data rate and/or increase possibility for a data rate of the link is derived from an identifier (for example a service class of the possible services or an identification of the mobile station) or from a signaled request of a mobile station for a service. These values can also be updated in the course of a link.

The optimization of the allocation is directed at a window of data rates for a link. In Fig. 5, in turn

some of the nodes are already occupied. The intention is to show the allocation of a CDMA code for a link with a data rate of 32 Kbit/s with a possibility of increase to a maximum of 64 Kbit/s. A node with a difference from an already occupied node is selected precisely at a specific position which corresponds to the increase possibility. The possibility of increase to 64 Kbit/s corresponds to the seventh position.

This is the case for the nodes 11111001 or 11111000 and 11110011 or 11110010, respectively. The difference between these nodes and the nodes 11111010 and 11110000 occurs precisely at the seventh position. Other free nodes already have differences at the sixth position (11110100) or not until the eighth position (11111111). Which of the two node pairs (11111001 or 11111000 and 11110011 or 111110010, respectively) will be shortlisted depends again on the optimization to the maximum or minimum. The selection between 11111001 or 11111000 and 11110011 or 11110010, respectively, is random here. As a peripheral condition it is to be noted again that the possibility of increasing the data rate should also be taken into account for already existing links. If a possibility of increase to 128 Kbit/s has been noted in advance for the link of the node 11110000, this is an exclusion criterion for the nodes 11110011 and 11110010.

If, for example, a link is to be operated with a data rate of 96 Kbit/s, two CDMA codes are to be assigned, to be precise either three 32 Kbit/s codes or one for 32 Kbit/s and a further for 64 Kbit/s. The allocation method is thus a multi-stage method. The desired data rate results from the totality of the individual data rates of the CDMA codes. For fig. 5 this means, for example, that depending on the optimization criterion one of the nodes 1111011, 1111010 or 1111001 is assigned for the 64 Kbit/s, and subsequently a remaining free node is selected for 32 Kbit/s. The allocation of a

CDMA code for the higher data rate should take place before the allocation of a CDMA code for the lower data rate.

The mobile radio system illustrated in fig. 6 as an example of a radio communications system is composed of mobile switching centers MSC which are interlinked to one another and/or constitute the access to a fixed network PSTN. Furthermore, these mobile switching centers MSC are connected to in each case at least one device RNC (radio network controller) for radio resource management. Each of these devices RNC in turn makes possible a link to at least one base station BS. Such a base station BS can set up, via a radio interface, a link to further radio stations, for example mobile stations MS or other mobile and fixed terminals. Fig. 6 represents by way of example links V1, V2, Vk for transmitting useful information and signaling information between mobile stations MS and a base station BS. An operations and maintenance center OMC carries out monitoring and maintenance functions for the mobile radio system and for parts of it.

The base station BS contains a storage device SP for storing the tree structure, the occupied nodes and the CDMA codes, as well as a program for carrying out the allocation method and a processing device BE for selecting a non-occupied node with corresponding CDMA code, and for assigning a channel with the CDMA code to a link in accordance with one of the previous strategies.